

# Checklist of freshwater symbiotic temnocephalans (Platyhelminthes, Rhabditophora, Temnocephalida) from the Neotropics

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<http://zoobank.org/286A18D5-FBB4-47E8-93D2-778718848F14>

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## Abstract

Received 20 July 2014

Accepted 1 September 2014

Published 10 October 2014

Academic editor:

David Gibson

## Key Words

*Temnocephala*

*Didymorchis*

*Diceratocephala*

Malacostraca

Insecta

Gastropoda

Chelonia

taxonomy

inventory

Based on published records and original data derived from our research, we have generated a checklist of symbiotic temnocephalan fauna from 57 taxa of freshwater invertebrate and vertebrate hosts from 16 families included in four classes from the Neotropics. The checklist contains 38 nominal species from 3 genera belonging to the Temnocephalida families Diceratocephalidae, Didymorchidae and Temnocephalidae. All taxa (35) of the genus *Temnocephala* are endemic to the Neotropics and 14 (40%) are considered micro-endemic (i.e. only one record each from a single locality). While only one species and one variety of *Didymorchis* are known from the Neotropics; there are also two putative undescribed species of this genus. Only *Diceratocephala boschmai* (Diceratocephalidae) is reported as an introduced species from Uruguay. Host specificity to a particular group of invertebrates and vertebrates is the first evidence for the ecological and evolutionary associations that will be analyzed in future studies.

## Introduction

Temnocephalida (Platyhelminthes, Rhabditophora) is the most diverse group of symbiotic turbellarians typically associated with crustaceans, with 122 valid species and 24 genera described in the world (Tyler et al. 2006–2012). Recently, Temnocephalida was confirmed as a monophyletic group included in Lymnophloplanida, which in turn makes up part of the Dalytyphloplanida clade, a major group of Rhabdocoela (Van Steenkiste et al. 2013). Within the Temnocephalida, the family Temnocephalidae Monticelli, 1899, is the most diverse, distributed in the Australian region with high species richness, but low host diversity, and in the Neotropics with an apparently lower number of temnocephalan species, but a greater diversity of host taxa (Damborenea and Brusa 2009, Sewell 2013). In fact,

in the Neotropics, 32 species belonging to the genus *Temnocephala* and four taxa belonging to *Didymorchis*, endemic to this region and associated with crustaceans, mollusks, insects and chelonians have been described (Damborenea and Cannon 2001b, Garcés et al. 2013 and cited therein).

The inventory work of the temnocephalan fauna in the Neotropics began in the 18<sup>th</sup> century, when the first species of Temnocephalida was described, *Temnocephala chilensis* (Moquin-Tandon 1846), associated with anomuran crabs, *Aegla laevis* (Latreille), from Chile (Damborenea and Cannon 2001a). Since then, more than 50 studies have been published regarding aspects of the temnocephalan fauna in the Neotropics, including descriptions of new species, analyses of temnocephalan symbiotic community structure of particular host species, and studies with phylogenetic and biogeographic inferences (e.g. Damborenea 1998, Volonterio 2007a,

Garcés et al. 2013). However, in many cases, information about the reported biodiversity in particular geographical locations of these rhabdocoel turbellarians is scattered among myriad bibliographic sources and difficult to access. Therefore, attempts to generate inventories and compile information are highly valuable for understanding the global diversity of freshwater flatworms (Schockaert et al. 2008). The main objectives of this paper are to compile all the available published accounts on the symbiotic freshwater temnocephalans from the Neotropics and to incorporate new data derived from our own work of the last few years to construct a checklist of symbiont-host associations.

## Material and methods

### Bibliographic search

All the published records on Neotropical temnocephalan species reported from Malacostraca (Decapoda), Gastropoda (Caenogastropoda), Insecta (Hemiptera, Megaloptera, Plecoptera and Trichoptera) and Reptilia (Testudines) strictly in freshwater systems were compiled. Databases such as Biological Abstracts, Biological and Agricultural Index Plus and Scopus, Google Scholar, Helminthological Abstracts, ISI Web of Knowledge, Turbellarian Taxonomic Database and Zoological Record were used to ensure that we retrieved all available information; the bibliographic search was undertaken up to June, 2014. We considered all the studies whose datasets provide taxonomic information regarding the Neotropical temnocephalan taxa, even those found in a single individual host. Papers containing compiled records of Neotropical temnocephalans that require taxonomic revisions due to problems were indicated (e.g. Vianna and Melo 2002). The host species names were used according with IUCN (2014), Tree of Life Web Project (Maddison and Schulz 2007), and with specific bibliography for Gastropoda (Cowie and Thiengo 2003) and Malacostraca (Melo 2003, De Grave and Ashelb 2013). Furthermore, a species accumulative curve (Dove and Cribb 2006) was obtained to evaluate the extent of the Neotropical symbiotic temnocephalan inventory.

### Survey work

Original data from our own studies of the last few years were included. A total of 11 taxa of decapod crustaceans of five families was examined for Argentine and Mexican temnocephalans. Furthermore, two species of Chelonia and one of Gastropoda from Argentina also were examined. Decapod crustaceans were collected with seine nets in one locality of central Mexico (Table 1). The collected decapod crustaceans were kept alive and examined for temnocephalans no more than 4 h after their capture. Decapod crustaceans were sacrificed and immediately examined for temnocephalans; external (e.g. carapace and claw surface) and internal structures (e.g. branchial cavity) were

analyzed separately in Petri dishes with 0.65% saline solution, under a stereomicroscope. Gills from each decapod were also obtained and placed in tap water to search for temnocephalans. In the case of mollusk hosts, their mantle cavity was opened after sacrificing. Temnocephalan collections from live turtles were carried out by the catch-and-release method (e.g. FAO 2012); therefore, the live turtles were identified directly in the field (L. Alcalde, personal communication). Temnocephalans were fixed with hot (steaming) 4% formalin or hot (steaming) distilled water. In some cases, specimens from the same host and with the same external aspect were fixed in 100% ethanol in the field for future molecular studies. All temnocephalans were processed following standard procedures (Sewell 2013). Species identification was achieved using specialized literature, and voucher specimens of some temnocephalans were deposited at the Colección Helmintológica of Museo de La Plata, Argentina (MLP-He) and the Colección Nacional de Helmintos (CNHE), Instituto de Biología, Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico, as follows: symbionts of Malacostraca (CNHE: 9276-9277; MLP-He: 6148-6155, 6218, 6641, 6763, 6768, 6770, 7153); symbionts of Gastropoda (MLP-He: 3050-3052, 6622, 6764-6767, 6769) and symbionts of Chelonia (MLP-He: 6642-6643).

## Results

In total, 60 papers have been published establishing host and locality records of the freshwater temnocephalan fauna in the Neotropics. The analysis of all available information (bibliographic and new original data) allowed us to establish a list of 38 symbiotic temnocephalan taxa in invertebrates and vertebrates in the Neotropical region, which are contained in four groups of hosts. Malacostraca (Decapoda): 4 taxa of *Didymorchis* associated with 3 taxa of crabs, 17 species of *Temnocephala* associated with 32 taxa of decapod crustaceans and only one species of *Dicercatocephala* associated with one species of decapod crustacean; Gastropoda (Caenogastropoda): 5 species of *Temnocephala* associated with 5 taxa of freshwater snail hosts; Insecta: 1, 2, 2 and 1 taxa of *Temnocephala* associated with 1, 5, 3 and 1 taxa hosts of Trichoptera, Hemiptera, Megaloptera and Plecoptera, respectively; Chelonia (Testudines): 4 taxa of *Temnocephala* associated with 7 species of freshwater turtle hosts.

The results of this study are presented in the Table 1 which shows the symbiont-host list, where temnocephalans are organized by taxonomic groups and ordered alphabetically by family name. Then species within each family are listed alphabetically followed by authority name and date. The next category is the host species in which the temnocephalids were found, followed by the locality, and the bibliographic reference from which the information was obtained, except for those records established in the present work. In the temnocephalan species found in more than one host species, the latter are listed alphabetically, and host

**Table 1.** Freshwater symbiotic Temnocephalida list from Neotropics. AR = Argentina; BR = Brazil; CL = Chile; CO = Colombia; CR = Costa Rica; MX = Mexico; PY = Paraguay; PE = Peru; UY = Uruguay. NR = Coordinates not reported. \*Coordinates not presented in the original work, but obtained for this study using Google Earth (<https://earth.google.com/>).

Symbiotic species	Host	Locality	Geographical coordinates	Reference
Temnocephalida Blanchard, 1849				
Temnocephaloidea Baer, 1953				
Family Didymorphichidae Bresslau and Reisinger, 1933				
<i>Didymorphichis haswelli</i> Mané Garzon, 1960	<i>Parastacus saffordi</i>	Aigüé, Lavalleya, UY	34°12'08"S; 54°46'16"W*	Mané-Garzon (1960)
<i>Didymorphichis haswelli</i> var. <i>australis</i> Dioni, 1972	<i>Parastacus</i> sp.	Nahuel Huapi National Park, Río Negro, AR	41°02'35"S; 71°28'06"W*	Dioni (1972)
<i>Didymorphichis</i> sp. 1	<i>Aegla neuquensis</i>	Nahuel Huapi Lake, Bariloche, Río Negro, AR	41°7'54.3"S; 71°19'51.5"W	Damborenea and Cannon (2001a)
<i>Didymorphichis</i> sp. 2	<i>Aegla neuquensis</i>	Nahuel Huapi Lake, Bariloche, Río Negro, AR	41°07'54.3"S; 71°19'51.5"W	Damborenea and Cannon (2001a)
Remarks. Dioni (1972) recorded <i>Didymorphichis haswelli</i> var. <i>australis</i> for Southwest of Argentina. Damborenea and Cannon (2001a) recorded <i>Didymorphichis</i> sp. 1 and <i>Didymorphichis</i> sp. 2 for the same area. These species will be described elsewhere.				
Family Diceratocephalidae Joffé, Cannon and Schockaert, 1998				
<i>Diceratocephala boschnai</i> Baer, 1953	<i>Cherax quadricarinatus</i>	Piriápolis, Maldonado, UY	34°58'S; 56°18'W	Volonteri (2009b)
Family Temnocephalidae Monticelli, 1899				
<i>Temnocephala axenos</i> Monticelli, 1899	<i>Aegla castro</i>	Curitiba, BR	25°25'0"S; 49°15'0"W*	Pérez González (1949)
	<i>Aegla franca</i>	Iatinga, São Paulo, BR	23°09'53"S; 48°37'4"W	Own findings
	<i>Aegla humahuaca</i>	La Chacra, Andalgala, Catamarca, AR	27°43'04"S; 55°54'15"W*	Dioni (1967c)
		Cochuna River, Tucumán, AR	27°21'49"S; 65°50'28"W*	Dioni (1967c)
		Tucumán, AR	26°49'26"S; 65°13'21"W*	Dioni (1967c)
	<i>Aegla laevis</i>	Blumenau, Santa Catarina, BR	26°55'10"S; 49°3'58"W*	Monticelli (1899)
	<i>Aegla platensis</i>	Colorado Stream (Route 6 km 35), Canelones, UY	34°39'S; 56°04'W	Volonteri (2007b)
		Martín García Island, Río de la Plata, AR	34°09'S; 58°15'W	Damborenea et al. (1997)
		Route 8 km 238, Lavalleya, UY	33°36'S; 56°35'W	Volonteri (2007b)
		Isla Paulino, Berisso, Río de la Plata, Buenos Aires, AR	34°49'41"S; 57°52'28"W	Damborenea et al. (1997)
		Martín García Island, Río de la Plata, AR	34°09'S; 58°15'W	Own findings
		Isla Paulino, Berisso, Río de la Plata, Buenos Aires, AR	34°49'41"S; 57°52'28"W	Damborenea (1992)
		Sangrador del Sur, Federación, Entre Ríos, AR	31°00'S; 57°53'W	Dioni (1967b)
		Aguas Blancas, Maldonado, UY	34°31'00'S; 55°27'00"W*	Dioni (1967b)
		Isla Paulino, Berisso, Río de la Plata, Buenos Aires, AR	34°49'41"S; 57°52'23"W	Own findings
		Cebollati River, Lavalleya, UY	33°9'21"S; 53°38'18"W*	Dioni (1967b)
	<i>Aegla</i> sp.	Dom Pedro Stream, Río Grande do Sul, BR	29°21'51"S; 49°51'12"W*	Dioni (1967b)
		Santa Lucía River, Lavalleya, UY	34°12'30"S; 56°21'30"W*	Dioni (1967b)
<i>Parastacus</i> sp.		Santa Lucía River, Montevideo, UY	34°47'10"S; 56°21'30"W	Dioni (1967b)
		Sauce Lagoon, Maldonado, UY	34°49'31"S; 55°33'7"W*	Dioni (1967b)
		Cerro do Jarau, Quaraí, Rio Grande do Sul, BR	30°11'23"S; 56°29'54"W*	Dioni (1967b)
		Negro River, Paso de Los Toros, Tacuarembó, UY	32°49'5"S; 56°30'23"W*	Dioni (1967b)
		Vila Jardim, Porto Alegre, Rio Grande do Sul, BR	30°1'58"S; 51°09'21"W*	Dioni (1967b)
		Barranca River (East), Punta Arenas, CR	9°57'32"N; 84°44'15"W*	Jennings (1968)
<i>Macrobrachium americanum</i>		Virilla River and tributaries, Alajuela, CR	9°55'50"N; 84°15'59"W*	Jennings (1968)

Symbiotic species	Host	Locality	Geographical coordinates	Reference
<i>Temnocephala brevicornis</i> Monticelli, 1889	<i>Acanthocheilus radiolata</i>	BR	NR	Monticelli (1889)
	<i>Acanthocheilus spixii</i>	Viamão, Rio Grande do Sul, BR	30°04'56.64"S; 51°01'11.81"W	Ferreira Yuki et al. (1993)
	<i>Hydromedusa maximiliani</i>	Angra dos Reis, Rio de Janeiro, BR	23°01'39"S; 44°19'55"W*	Pereira and Cuocolo (1940)
		BR	NR	Monticelli (1889)
		BR	NR	Merton (1922)
		Juiz de Fora, Minas Gerais, BR	21°41'20"S; 43°20'40"W	Novelli et al. (2009)
		Rezende, Rio de Janeiro, BR	22°28'16"S; 44°27'04"W*	Pereira and Cuocolo (1941)
		Terezopolis, Rio de Janeiro, BR	22°25'01.06"S; 42°58'32.17"W*	Pereira and Cuocolo (1940)
		Vçosa, Minas Gerais, BR	20°45'17.52"S; 42°52'42.88"W	Pereira and Cuocolo (1940)
		Carnaval Stream, City Bell, Buenos Aires, AR	34°53'46"S; 58°05'39"W	Own findings
<i>Hydromedusa tectifera</i>	<i>Trachemys dorbigni</i>	Chubichamini Stream, Magdalena, Buenos Aires, AR	35°03'55.37"S; 57°37'37.24"W	Own findings
		Valle Edén, Tacuarembó, UY	31°49'11"S; 56°10'37"W*	Dioni (1967b)
		Villoldo Stream, Magdalena, Buenos Aires, AR	35°15'56"S; 57°15'32"W*	Brusa and Damborenea (2000)
		Varginha, São Paulo, BR	NR	Pereira and Cuocolo (1940)
		BR	NR	Monticelli (1889)
<i>Temnocephala caddisfyi</i> Amato, Amato and Seixas, 2011	<i>Mesoclemmys gibba</i>	Chubichamini Stream, Magdalena, Buenos Aires, AR	35°03'55"S; 57°37'37"W	Own findings
	<i>Phrynops hilarii</i>	Viamão, Rio Grande do Sul, BR	30°04'56.64"S; 51°01'11.81"W	Ferreira Yuki et al. (1993)
	<i>Trachemys dorbigni</i>	Remarks. Caballero and Cerecero (1951) mentioned because of the probable misidentification of the specimens.		
	<i>Barypenthus</i> sp.	Córrego das Pedras, Serra do Cipó National Park, Jaboticatubas, BR	19°22'10"S; 43°35'53"W	Amato et al. (2011)
	<i>Aegla abiao</i>	Limay River, Neuquén, AR	38°59'31"S; 68°03'51"W*	Damborenea (1992)
	<i>Aegla affinis</i>	Telsen Stream, Chubut, AR	42°38'35.2"S; 66°52'18.0"W	Own findings
	<i>Aegla jujuyana</i>	Chico River, Jujuy, AR	24°11'14"S; 65°17'14"W	Dioni (1967c)
	<i>Aegla laevis</i>	Taca River, CL	35°25'53.51"S; 71°38'18.57"W	Dioni (1967c)
	<i>Aegla neuquensis</i>	Covunco Stream, Neuquén, AR	38°47'603"S; 70°11'402"W*	Damborenea (1992)
	<i>Aegla riolimayana</i>	Nahuel Huapi Lake, Rio Negro, AR	41°02'35"S; 71°28'06"W*	Dioni (1967c)
<i>Temnocephala chilensis</i> (Moquin-Tandon, 1846)	<i>Aegla</i>	El Carrizal, Luján de Cuyo, Mendoza, AR	33°20'03"S; 68°43'44"W*	Dioni (1967c)
		Fortín 1° de Mayo Stream, Neuquén, AR	39°25'31"S; 70°41'11"W*	Damborenea (1992)
		Limay River, Neuquén, AR	38°59'31"S; 68°03'51"W*	Dioni (1967c)
		Llao-Llao Stream, Neuquén, AR	39°17'30"S; 70°36'12"W	Damborenea (1992)
		Loncopué, Neuquén, AR	38°04'47"S; 70°36'47"W	Dioni (1967c)
	<i>Aegla scamosa</i>	Mendoza River, Potrerillos, Mendoza, AR	32°20'03"S; 68°43'44"W*	Damborenea (1992)
		Ñireco Stream, Neuquén, AR	37°20'08"S; 70°43'20"W	Damborenea (1992)
		Posadas Misiones, AR	27°22'10"S; 55°53'42"W*	Dioni (1967c) (+)
		Valparaiso, Santiago, CL	33°30'45"S; 70°40'35"W*	Wacke (1905)
		Zapala, Neuquén, AR	38°54'02"S; 70°40'11"W*	Dioni (1967c)
<i>Aegla</i> sp.		Chos-Malal, Neuquén, AR	37°22'41"S; 70°16'15"W*	Dioni (1967c)
		Diamante River, San Rafael, Mendoza, AR	34°36'479"S; 68°36'041"W	Own findings
		Grande River, Route 40, Mendoza, AR	35°5'525"S; 69°48'468"W	Own findings
		Lacar Lake, Neuquén, AR	40°10'10"S; 71°30'32"W*	Dioni (1967a)

Symbiotic species	Host	Locality	Geographical coordinates	Reference
<i>Temnocephala colombiensis</i> Garcés, Puerta, Tabares, Lenis and Velásquez, 2013 <i>Temnocephala costarricensis</i> Lamothe, 1974 <i>Temnocephala cuocoloi</i> Volonteiro, 2010	<i>Parastacus</i> sp. <i>Samastacus</i> sp.	Meliquina River, flows into Meliquina Lake, Neuquén, AR	40°23.007'S; 71°15.916'W	Own findings
		Nahuel Huapi Lake, Rio Negro, AR	41°02'35"S; 71°28'06"W*	Dioni (1967c), Dioni (1972)
		Near Santiago city, CL	33°28'08"S; 70°38'31"W*	Moquin-Tandon (1846)
		Paraná River, Rosario, Santa Fe, AR	32°57'03"S; 60°37'07"W*	Dioni (1967c) (+)
		Uspallata, Mendoza, AR	32°39'14"S; 69°22'02"W*	Dioni (1967c)
<i>Temnocephala curviciirri</i> Amato and Amato, 2005 <i>Temnocephala cyanoglandula</i> Amato, Amato and Daudt, 2003 <i>Temnocephala decarloi</i> Moretto, 1978 <i>Temnocephala digitata</i> Monticelli, 1902 <i>Temnocephala digitata</i> Monticelli, 1902 [sensu Dioni 1966] <i>Temnocephala haswelli</i> Ponce de León, 1989	<i>Pomacea</i> sp. <i>Pseudophilopha tristanti</i> <i>Hydromedusa tectifera</i> <i>Belostoma dentatum</i> <i>Belostoma dilatatum</i> <i>Belostoma elegans</i> <i>Belostoma testaceopallidum</i> <i>Aegla serrana</i> <i>Belostoma cummingsi</i> <i>Palaemon argentinus</i> <i>Palaemon</i> sp. <i>Pomacea canaliculata</i>	Nahuel Huapi Lake, Rio Negro, AR	41°02'35"S; 71°28'06"W*	Damborenea (1992)
		Tumbes, Talcahuano, CL	NR	Wacke (1905)
		Limay River, Rincón de Creide, Neuquén, AR	40°47.145'S; 71°07.084'W	Own findings
		San José del Nís Ponds, San Roque, Antioquia, CO	6°29'51"N; 74°50'28"W	Garcés et al. 2013
		Rincón de Osa, Punta Arenas, CR	9°58'00"N; 84°50'00"W*	Lamothe-Argumedo (1974)
<i>Temnocephala digitata</i> Monticelli, 1902 <i>Temnocephala digitata</i> Monticelli, 1902 [sensu Dioni 1966] <i>Temnocephala haswelli</i> Ponce de León, 1989	<i>Asolene platane</i>	Barra de Carrasco, Canelones, UY	34°52'S; 56°02'W	Volonteiro (2010)
		Colorado Stream, Canelones, UY	34°38'S; 56°03'W	Volonteiro (2010)
		State of Minas Gerais, BR	NR	Amato and Amato (2005)
		Taruma Lake, Rio Grande do Sul, BR	30°04'14"S; 51°01'20"W	Amato and Amato (2005)
		Stream and canal, Arrozeira, Eldorado do Sul, Rio Grande do Sul, BR	30°01'36"S; 51°22'42"W	Amato and Amato (2005)
<i>Temnocephala digitata</i> Monticelli, 1902 <i>Temnocephala digitata</i> Monticelli, 1902 [sensu Dioni 1966] <i>Temnocephala haswelli</i> Ponce de León, 1989	<i>Asolene platane</i>	Retiro das Pedras, Brumadinho, Minas Gerais, BR	20°04'S; 44°00'W	Amato and Amato (2005)
		Creek and a small reservoir in the Utopia II Farm, Cambará do Sul, Rio Grande do Sul, BR	29°15'10"S; 50°15'45"W	Amato et al. (2003)
		Otamendi, Paraná Delta, Buenos Aires, AR	34°13'S; 58°53'W*	Moretto (1978)
		Freshwater bodies from Buenos Aires, in communication with Rio de la Plata, AR	NR	Monticelli (1902)
		Los Talas, Berisso, Buenos Aires, AR	34°53'18"S; 57°49'49"W	Damborenea (1992)
<i>Temnocephala digitata</i> Monticelli, 1902 <i>Temnocephala digitata</i> Monticelli, 1902 [sensu Dioni 1966] <i>Temnocephala haswelli</i> Ponce de León, 1989	<i>Asolene platane</i>	La Virgen Stream, UY	34°25'15"S; 56°23'43"W*	Own findings
		Arrozeira, Eldorado do Sul, Rio Grande do Sul, BR	30°01'36"S; 51°22'42"W	Dioni (1966)
		Cachoeira Barragem do Cerrito, Barra do Ouro, Maquiné, Rio Grande do Sul, BR	29°34'15"S; 50°16'51"W	Seixas et al. (2010c)
		Canelón Chico Stream, Canelones, UY	34°29'00"S; 56°20'00" W*	Ponce de León (1989)
		Cañada Totoral (Route 107, km 21), Canelones, UY	34°32'S; 56°13'W	Volonteiro (2007a)
<i>Temnocephala digitata</i> Monticelli, 1902 <i>Temnocephala digitata</i> Monticelli, 1902 [sensu Dioni 1966] <i>Temnocephala haswelli</i> Ponce de León, 1989	<i>Asolene platane</i>	Jacuí River, Ilha da Pintada, Porto Alegre, Rio Grande do Sul, BR	30°02'23"S; 51°25'49"W	Seixas et al. (2010c)
		Parque Marilina de Brasil, Porto Alegre, BR	30°03'34"S; 51°13'49"W	Seixas et al. (2010c)
		Paso del Horno (Route 6, km 5), Sauce Stream, Canelones, UY	34°38'S; 56°03'W	Volonteiro (2007a)
		Ponta do Ceroula, Barra do Ribeiro, BR	30°15'07.51"S; 51°16'49.55"W	Seixas et al. (2010c)
		Praia Florida, Guaíba, Rio Grande do Sul, BR	30°15'54"S; 51°22'25"W	Seixas et al. (2010c)
<i>Temnocephala digitata</i> Monticelli, 1902 <i>Temnocephala digitata</i> Monticelli, 1902 [sensu Dioni 1966] <i>Temnocephala haswelli</i> Ponce de León, 1989	<i>Asolene platane</i>	Sarandí Chico Stream (Route 3, km 176), Flores, UY	33°37'S; 56°51'W	Volonteiro (2007a)
		Sava Clube, Guaíba Lake, Porto Alegre, BR	30°06'09"S; 51°15'57.5"W	Seixas et al. (2010c)
		Tacuari River (Route 8, km 376), Cerro Largo, UY	32°31'S; 54°07'W	Volonteiro (2007a)
		Madrejon Don Felipe, Santa Fe, AR	NR	Damborenea (1992)
		Malabrigo Stream, tributary of the Rio San Javier, Santa Fe, AR	29°27'00"S; 59°44'00"W*	Hyman (1955)
<i>Temnocephala digitata</i> Monticelli, 1902 <i>Temnocephala digitata</i> Monticelli, 1902 [sensu Dioni 1966] <i>Temnocephala haswelli</i> Ponce de León, 1989	<i>Pomacea canaliculata</i>	Atalaya, Río de la Plata, Buenos Aires, AR	35°00'42"S; 57°32'02.7"W	Own findings
		Blagiardi beach, Río de la Plata estuary, Buenos Aires, AR	35°55'S; 57°49'W	Damborenea et al. (2006)

Remarks. Taking into account the known distribution of *T. chilensis*, the citations marked with (+) are considered doubtful.



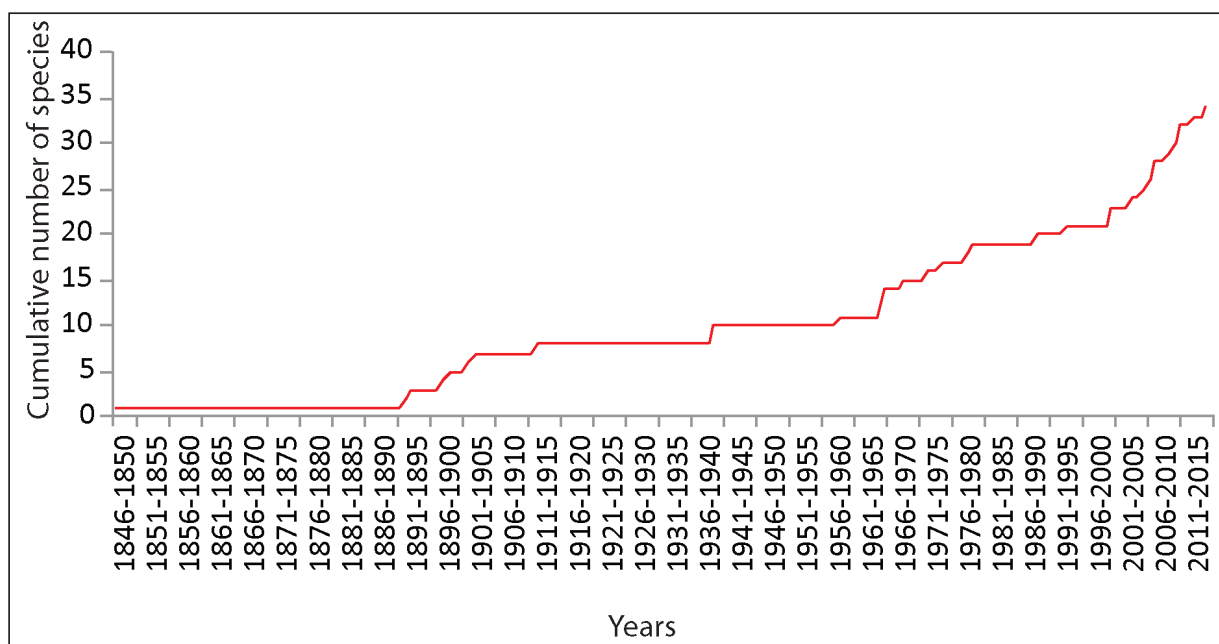
Symbiotic species	Host	Locality	Geographical coordinates	Reference
		Temporal body water, Route 14, Entre Ríos, AR	33°21'11"S; 58°48'41"W	Own findings
		Bird Observatory, Rocha, UY	33°54'S; 53°40'W	Volonterio (2007a)
		Bridge over Andreoni channel, Rocha, UY	33°54'S; 53°40'W	Volonterio (2007a)
		Bridge over cañada, Rocha, UY	33°51'S; 53°55'W	Volonterio (2007a)
		Bridge over the Averías Stream, Rocha, UY	33°53'S; 53°51'W	Volonterio (2007a)
		Cachoeira River, Barragem do Cerrito, Barra do Ouro, Maquiné, Rio Grande do Sul, BR	29°34'15"S; 50°16'51"W	Seixas et al. (2010a)
		Cañada 1, Soriano, UY	33°12'S; 57°27'W	Volonterio (2007a)
		Cañada del Ceibo, Colonia, UY	34°40'S; 56°03'W	Volonterio (2007a)
		Channels around rice, Arrozeira, Eldorado do Sul, Rio Grande do Sul, BR	30°01'36"S; 51°22'42"W	Seixas et al. (2010a)
		Chapaleofu Stream, Buenos Aires, AR	36°48'53"S; 59°08'05"W	Martin et al. (2005)
		Chasicó Stream, near Los Chilenos Lake, Buenos Aires, AR	38°09'59"S; 62°36'02"W	Martin et al. (2005)
		Colonia city, near the wall, Colonia, UY	34°28'S; 57°50'W	Volonterio (2007a)
		Doña Flora Stream, Buenos Aires, AR	34°50'57"S; 57°55'20"W*	Damborenea (1992)
		El Fuerte reservoir at Tandil city, Buenos Aires, AR	37°20'41"S; 59°07'45"W	Martin et al. (2005)
		El Pescado stream, near the Río de la Plata estuary, Buenos Aires, AR	34°57'S; 57°46'W	Damborenea et al. (2006)
		Kalél Huincul reservoir, Route 2, Buenos Aires, AR	36°47'36"S; 57°46'29"W	Martin et al. (2005)
		Fazenda Sossego, Santa Vitória do Palmar, Rio Grande do Sul, BR	33°16'13"S; 53°26'28"W	Seixas et al. (2010a)
		India Muerta Stream, Rocha, UY	33°46'S; 54°05'W	Volonterio (2007a)
		Interbalnearia Route, Canelones, UY	NR	Flecher and Ponce de León (1983)
		Italia Avenue, Canelones, UY	NR	González et al. (1987)
		Juncal Stream, Flores, UY	33°29'S; 56°58'W	Volonterio (2007a)
		La Lancha Stream, Soriano, UY	33°37'S; 57°38'W	Volonterio (2007a)
		Langueyú Stream, Buenos Aires, AR	36°40'24"S; 58°26'42"W	Martin et al. (2005)
		Los Chilenos lake, Fishing Club Tomquist, Buenos Aires, AR	38°02'37"S; 62°31'01"W	Martin et al. (2005)
		Los Padres lake, Buenos Aires, AR	37°56'06"S; 57°43'54"W	Martin et al. (2005)
		Los Talas, Berisso, Buenos Aires, AR	34°53'00"S; 57°49'57"W	Damborenea (1992)
		Los Talas lagoon, near the Río de la Plata estuary, Buenos Aires, AR	34°57'S; 57°46'W	Damborenea et al. (2006)
		Martín García Island, Río de la Plata, AR	34°10'45"S; 58°15'08"W	Own findings
		Miguelín Stream, Punta Lara, Ensenada, Buenos Aires, AR	34°48'00"S; 57°50'22"W	Damborenea (1992)
		Paraná Medio, AR	30°02'23"S; 51°25'49"W	Di Persia and Radici de Cura (1973)
		Paso de la Cruz, tributary of Bequeló Stream, Soriano, UY	33°13'S; 57°55'W	Volonterio (2007a)
		Paso de Las Piedras reservoir, Buenos Aires, AR	38°24'32"S; 61°44'37"W	Martin et al. (2005)
		Ponta do Ceroula, Barra do Ribeiro, Rio Grande do Sul, BR	30°15'7.51"S; 51°16'49.55"W	Seixas et al. (2010a)
		Praia Florida, Guaíba, Rio Grande do Sul, BR	30°15'54"S; 51°32'25"W	Seixas et al. (2010a)
		Punta Indio, Buenos Aires, AR	35°19'S; 57°13'W	Damborenea (1992)
		Jacuí River, at Ilha da Pintada, Porto Alegre, Rio Grande do Sul, BR	30°22'23"S; 51°25'49"W	Seixas et al. (2010a)
		Route 4 near Los Charruas, Entre Ríos, AR	31°21'11"S; 58°6'16"W	Own findings
		San Pedro Stream, Colonia, UY	34°18'S; 57°52'W	Volonterio (2007a)
		Sarandí Chico Stream, Flores, UY	33°37'S; 56°51'W	Volonterio (2007a)
		Sarandí del Consejo Stream, Rocha, UY	34°15'S; 53°59'W	Volonterio (2007a)

Symbiotic species	Host	Locality	Geographical coordinates	Reference
<i>Temnocephala kingsleyae</i> Damborenea, 1994 <i>Temnocephala lamothei</i> Damborenea and Brusa, 2008 <i>Temnocephala lanei</i> Pereira and Cuocolo, 1941 <i>Temnocephala longivaginata</i> Seixas, Amato and Amato, 2011	<i>Pomacea lineata</i> <i>Pomella megastoma</i> <i>Pomacea</i> sp. <i>Kingsleya ytuporta</i> <i>Pomella megastoma</i> <i>Trichodactylus</i> sp. <i>Dilodactylus septemdentatus</i> <i>Sylviocarcinus pictus</i> <i>Telphusa</i> sp. <i>Trichodactylus fluviatilis</i> <i>Trichodactylus panoplus</i> <i>Trichodactylus petropolitamus</i> <i>Trichodactylus</i> sp. <i>Aegla platensis</i> <i>Procambarus digueti</i> <i>Pseudothelphusa jouyi</i>	Sauce Stream, Canelones, UY	34°38'S; 56°3'W	Volonteri (2007a)
		Sava Clube, Guaíba Lake, Porto Alegre, Rio Grande do Sul, BR	30°06'09"S; 51°15'57.5"W	Seixas et al. (2010a)
		Savedra Park, La Plata, Buenos Aires, AR	34°55'52.1"S; 57°56'31.58"W	Own findings
		Stream 1, Rocha, UY	33°26'S; 53°52'W	Volonteri (2007a)
		Stream 2, Rocha, UY	33°24'S; 53°51'W	Volonteri (2007a)
		Strem near Route 11, Magdalena, AR	34°57'51.53"S; 57°48'09.1"W	Own findings
		Zapata Stream, Magdalena, AR	34°59'18"S; 57°43'00"W*	Damborenea (1992)
		Guaiacurus, Mato Grosso do Sul, BR	20°51'S; 56°45'W*	Pereira and Cuocolo (1941)
		Salobra, Mato Grosso do Sul, BR	20°10'S; 56°31'W*	Pereira and Cuocolo (1941)
		Martin Garcia Island, Rio de la Plata, AR	34°10'45"S; 58°15'08"W	Damborenea et al. (1997)
		BR	NR	Haswell (1893)
		San Jose, UY	34°15'S; 56°45'W*	Dioni (1967b)
		Soriano, UY	33°30'S; 57°45'W*	Dioni (1967b)
		Araguari River, Amapa, BR	1°15'0"N; 49°55'0"W*	Damborenea (1994)
		Yaboti-Mini Stream, Misiones, AR	26°57'39"S; 53°49'23"W	Damborenea and Brusa (2008)
<i>Temnocephala lutzii</i> Monticelli, 1913	Juquía, São Paulo, BR	24°11'22"S; 47°38'7"W*	Pereira and Cuocolo (1941)	
	Peixe-Boi River, Peixe-Boi, Pará, BR	1°07'17"S; 47°18'48"W	Seixas et al. (2011)	
	Amapa River, Cachoeira Grande, BR	2°09'S; 50°55'W*	Damborenea (1994)	
	Negro River, Lago do Prato, Arquipélago das Anavilhanas, BR	2°09'S; 60°51'W	Damborenea (1994)	
	São Paulo, BR	NR	Monticelli (1913)	
	Carvao Stream, Maquiné, Rio Grande do Sul, BR	29°32'29"S; 50°13'49"W	Amato et al. (2005)	
	Agua Parada Stream, Maquiné, Rio Grande do Sul, BR	29°66'20"S; 50°21'15"W	Amato et al. (2005)	
	Forqueta Stream, Maquiné, Rio Grande do Sul, BR	29°32'17"S; 50°14'44"W	Amato et al. (2005)	
	Vale das Trutas, head waters of Rio das Antas, São José dos Ausentes, Rio Grande do Sul, BR	28°47'00"S; 49°50'53"W	Amato et al. (2005)	
	Arrozeira, Eldorado do Sul, Rio Grande do Sul, BR	30°01'36"S; 51°22'42"W	Amato et al. (2005)	
	Boticario Stream (Route 14, km 3), Soriano, UY	33°13'S; 57°55'W	Volonteri (2007a)	
	do Conte Stream, Guaíba, BR	30°05'73"S; 51°32'63"W	Amato et al. (2005)	
	Jacui River, Ilha da Pintada, Guaíba Lake, Porto Alegre, Rio Grande do Sul, BR	30°02'23"S; 51°25'49"W	Amato et al. (2005)	
	Praia Florida, Guaíba Lake, Guaíba, Rio Grande do Sul, BR	30°15'54"S; 51°32'25"W	Amato et al. (2005)	
	Bairro Pinheiros, São Paulo, BR	22°32' 2"S; 44°53'16"W*	Pereira and Cuocolo (1941)	
<i>Temnocephala mertoni</i> Volonteri, 2007 <i>Temnocephala mexicana</i> Vayssiére, 1898	Piracicaba, São Paulo, BR	22°43'31"S; 47°38'57"W*	Pereira and Cuocolo (1941)	
	Cochá Yanayacu, Pacaya-Samiria, Loreto, PE	5°17'46"S; 74°25'33"W	Noreña et al. (2006)	
	Colorado Stream, Canelones, UY	34°41' S; 56°04'W	Volonteri (2007b)	
	Molles Stream, Lavalleja, UY	33°36' S; 54°35' W	Volonteri (2007b)	
	Camecuaro Lake, Michoacan, MX	19°54'12"N; 102°12'37"W	Lamothe-Argumedo (1968), Own findings	
	Chapala Lake, Jalisco, MX	20°15'N; 103°00'W	Lamothe-Argumedo (1980)	
	Camecuaro Lake, Michoacan, MX	19°54'12"N; 102°12'37"W	Lamothe-Argumedo (1968), Own findings	
	Remarks: Dioni (1972) mentioned <i>T. mexicana</i> on <i>Aegla</i> sp. and <i>Parastacia</i> sp. from Nahuel Huapi Lake, Rio Negro, AR 41°02'35"S; 71°28'06"W.			

Symbiotic species	Host	Locality	Geographical coordinates	Reference
<i>Temnocephala microdactyla</i> Monticelli, 1903	<i>Dilocarcinus pagei</i>	Guadalupe Lagoon, Santa Fe, AR	31°39'S; 60°42'W	Dioni (1967d)
		Mato Grosso, BR	NR	Monticelli (1903)
	<i>Syviocarcinus australis</i>	Piedras Blancas, Guadalupe Lagoon, Santa Fe, AR	31°39'S; 60°42'W	Damborenea (1992)
<i>Temnocephala minutocirrus</i> Amato, Seixas and Amato, 2007	<i>Syviocarcinus pictus</i>	Piedras Blancas, Guadalupe Lagoon, Santa Fe, AR	31°39'S; 60°42'W	Damborenea (1992)
		Bodoquena, Mato Grosso, BR	20°32' 9"S; 56°42'54"W*	Pereira and Cuocolo (1941)
	<i>Cryptocercos granulosis</i>	Forqueta Stream, Barra do Ouro, Maquiné, Rio Grande do Sul, BR	29°32'19"S; 50°14'47"W	Amato et al. (2007)
		Garapiá Stream, Barra do Ouro, Maquiné, Rio Grande do Sul, BR	29°30'23"S; 50°14'38"W	Amato et al. (2007)
		Rio da Divisa, São José dos Ausentes, Rio Grande do Sul, BR	28°38'17"S; 049°57'46"W	Amato et al. (2007)
		Barra de Carrasco, Canelones, UY	34°52'S; 56°02'W	Volonteri (2010)
	<i>Hydromedusa tectifera</i>	Colorado Stream, Canelones, UY	34°38'S; 56°03'W	Volonteri (2010)
	<i>Temnocephala perei</i> Volonteri, 2010	Numpatkem and Kumpinentsa, Marañón River, Imaza, Bagua, PE	4°59'34"S; 78°23'38"W*	Ibáñez Herrera and Jarab (2003)
		Candinho stream, Ecological Station, Bebedouro, São Paulo, BR	20°56'58"S; 48°28'43"W	Amato et al. (2010)
		Fazenda Ypiranga, Poconé, 10 km south of Poconé and 110 km from Cuiabá, Mato Grosso, BR	16°20'14"S; 56°38'58"W	Amato et al. (2010)
<i>Temnocephala pignallbertae</i> Dioni, 1967	<i>Dilocarcinus pagei</i>	Guadalupe Lake, Piedras Blancas, Santa Fe, AR	31°39'S; 60°42'W*	Damborenea (1992)
		Los Espejos Lagoon, Santa Fe, AR	NR	Dioni (1967d)
		Madrejón Don Felipe, Santa Fe, AR	NR	Dioni (1967d)
		Piedras Blancas, Guadalupe Lagoon, Santa Fe, AR	31°39'S; 60°42'W*	Damborenea (1992)
	<i>Syviocarcinus australis</i>	Salado River, Santo Tomé, Santa Fe, AR	31°41'01"S; 60°44'35"W*	Dioni (1967d)
		Guadalupe Lake, Santa Fe, AR	31°33'46"S; 60°36'20"W*	Dioni (1967d)
		Madrejón Don Felipe, Santa Fe, AR	NR	Dioni (1967d)
		Piedras Blancas, Guadalupe Lagoon, Santa Fe, AR	31°39'S; 60°42'W*	Damborenea (1992)
	<i>Trichodactylus pamophilus</i>	Boticario Stream (Route 14, km 3), Soriano, UY	33°13'S; 57°55'W	Volonteri (2007a)
		Madrejón Don Felipe, Santa Fe, AR	NR	Dioni (1967d)
<i>Temnocephala rochenensis</i> Ponce de León, 1979	<i>Trichodactylus</i> sp.	Paraná, Entre Ríos, AR	31°43'55"S; 60°31'25"W	Dioni (1967d)
	<i>Pomacea canaliculata</i>	Bird Observatory (Route 14, km 487), Rocha, UY	33°54'S; 53°40'W	Volonteri (2007a)
		Cebollati River (Route 15, km 195), UY	33°14'S; 53°47'W	Volonteri (2007a)
		Channel on the road to São Lorenzo do Sul, BR	31°20'21.4"S; 52°03'10"W	Seixas et al. (2010b)
		Juncal Stream, Fazenda da Invernada, BR	32°27'08.8"S; 53°15'44.6"W	Seixas et al. (2010b)
		Fazenda Sossego, 30 km west of Santa Vitoria do Palmar, BR	33°16'13"S; 53°26'28"W	Seixas et al. (2010b)
		Negro Lake, Rocha, UY	34°01'S; 53°36'W	Ponce de León (1979)
		Pond at Fazenda da Invernada, BR	32°27'41"S; 53°15'14"W	Seixas et al. (2010b)
		Route 15, km 202, Pond, UY	33°13'S; 53°48'W	Volonteri (2007a)
		Route 14, km 446, India Muerta stream, UY	33°46'S; 54°05'W	Volonteri (2007a)
		Route 14, km 469, Bridge on the Averías Stream, UY	33°53'S; 53°51'W	Volonteri (2007a)
		Sarandi del Consejo Stream (Route 9 km 251), UY	34°15'S; 53°59'W	Volonteri (2007a)
		Side way ditch on the road to Fazenda São João 2, Jaguarão, BR	32°35'29.7"S; 53°14'04.5"W	Seixas et al. (2010b)
		Side way pond, Interstate Road 116 (km 12), BR	32°28'21"S; 53°17'20"W	Seixas et al. (2010b)
		Route 15, km 195, Stream, Rocha, UY	33°26'S; 53°52'W	Volonteri (2007a)



Symbiotic species	Host	Locality	Geographical coordinates	Reference
<i>Temnocephala santafesina</i> Dioni, 1967	<i>Dilocarcinus pageti</i>	Los Espejos Lagoon, Santa Fe, AR	NR	Dioni (1967d)
		Madrejon Don Felipe, Santa Fe, AR	NR	Dioni (1967d)
		Piedras Blancas, Guadalupe Lagoon, Santa Fe, AR	31°39'S; 60°42'W*	Damborenea (1992)
		Cerrado formation municipality, BR	19°57'10"S; 40°32'25"W	Trivinho-Strixino et al. (2012)
<i>Temnocephala</i> sp.	<i>Corydalis</i> sp.	Cerrado formation municipality, BR	19°57'10"S; 40°32'25"W	Trivinho-Strixino et al. (2012)
<i>Temnocephala</i> sp.	<i>Protochaetodon</i> sp.	Rivers of Estação Biológica de Santa Lúcia, Santa Teresa, Espírito Santo, BR	19°57'10"S; 40°32'25"W	Avelino-Capistrano et al. (2013)
<i>Temnocephala</i> sp.	<i>Hydromedusa tectifera</i>	Palma, Encruzilhada do Sul, BR	30°34'-30°43'S; 52°30'-52°51'W	Soares et al. (2007)
<i>Temnocephala talicei</i> Dioni, 1967	<i>Aegla platensis</i>	Anchorena Stream, Martínez, Buenos Aires, AR	34°29'20"S; 58°28'53"W*	Damborenea (1992)
		Lavalleja (Route 8, km 238), UY	33°36'S; 54°35'W	Volonteri (2007a)
		Martin García Island, Río de la Plata, Buenos Aires, AR	34°10'45"S; 58°15'08"W	Damborenea et al. (1997)
		Villa Rica, PY	25°46'50"S; 56°26'55"W*	Dioni (1968)
<i>Temnocephala talicei</i> Dioni, 1967	<i>Aegla prado</i>	El Prado Botanic Garden, Montevideo, UY	34°49'S; 56°12'W	Volonteri (2009b)
	<i>Aegla uruguayana</i>	Martin García Island, Río de la Plata, Buenos Aires, AR	34°10'45"S; 58°15'08"W	Damborenea et al. (1997)
		Moller Stream (Route 8, km 238), Lavalleja, UY	33°36'S; 56°35'W	Volonteri (2009b)
		Olivos, Buenos Aires, AR	33°30'S; 63°10'W*	Damborenea (1992)
	<i>Aegla</i> sp.	Paulino Island, Río de la Plata, Buenos Aires, AR	34°50'08"S; 57°52'44"W	Damborenea (1992)
		Lunarejo Stream, Rivera, UY	31°15'0"S; 55°50'0"W*	Dioni (1967b)
		De Doll Stream, Route 11, Entre Ríos, AR	32°18'37"S; 60°25'54"W	Own findings
		Tres Islas, Cerro Largo, UY	32°34'0"S; 53°38'0"W*	Dioni (1967b)
		Prado, Montevideo, UY	NR	Dioni (1967b)
		Agua Parada Stream, Maquiné River Basin, Maquiné, Río Grande do Sul, BR	29°66'20"S; 50°21'15"W	Amato et al. (2006)
<i>Temnocephala trapeziformis</i> Amato, Amato and Seixas, 2006	<i>Trichodactylus fluviatilis</i>	Carvão Stream, Maquiné River Basin, Maquiné, Río Grande do Sul, BR	29°32'29"S; 50°13'49"W	Amato et al. (2006)
		Forqueta Stream, Maquiné River Basin, Maquiné, Río Grande do Sul, BR	29°32'17"S; 50°14'44"W	Amato et al. (2006)
		Vale das Trutas head waters of Rio das Antas, Taquari-Antas basin, São Jose dos Ausentes, Rio Grande do Sul, BR	28°47'00"S; 49°50'53"W	Amato et al. (2006)
<i>Temnocephala travassosfilloei</i> Pereira and Cuocolo, 1941	<i>Trichodactylus petropolitamus</i>	San Bernardo, São Paulo, BR	22°00'S; 49°00'W	Pereira and Cuocolo (1941)



**Figure 1.** Accumulative species curve for freshwater symbiotic *Temnocephala* fauna in Neotropics.

species for which more than one locality was recorded, are listed together. Furthermore, a host-symbiont list (See Appendix 1) is taxonomically and alphabetically organized.

The decapods are the most species-rich host group with temnocephalans (27), followed by the insects (5 taxa) and snails (5 species). Of the 38 taxa of Temnocephalidae listed in this work, all appear to be specific to particular host groups, while at least only one species of the family Diceratocephalidae have successfully associated with hosts after their anthropogenic introduction, i.e. *Diceratocephala boschmai*. The most widely distributed species are *T. axenos*, *T. chilensis* and *T. iheringi*, which are present in 9 and 10 crab host species and 5 snail host species, along 20, 25 and 49 localities, respectively.

In terms of hosts, *Hydromedusa tectifera* (a turtle) is the host with the highest temnocephalan species richness with 4 taxa, followed by *Aegla neuquensis*, *A. platensis*, *Dilocarcinus pagei* (decapod crabs) and *Pomacea canaliculata* (snail), all with 3 species; meanwhile, 49 host taxa show only one record of temnocephalid taxa for one locality.

The species accumulation curve for Neotropic temnocephalans plotted against the total number of species (Figure 1) shows irregular growth over 15 decades of studies in Temnocephalida (each decade divided into two periods of five years). This graph shows that the asymptote has not been reached yet and, if the systematic studies of the group are continued, a significant increase in the number of species in the Neotropical region can be expected. This graphic also reflects two important periods of research. The first shows the initial prospecting for temnocephalid species in the Neotropical region, between 1890 and the beginnings of the 20th century. The second period, beginning around 1970, shows an increase in the research on temnocephalans from different host species, with some stationary periods.

## Discussion

The genus *Temnocephala* is an endemic component of the Neotropical region (Damborenea and Cannon 2001a). At the moment, it includes 35 taxa, of which 14 (40%) are considered microendemic (only one record for locality) (Table 1). In total, 57 host taxa are associated with one or more temnocephalan taxa, which belong to seven orders and 14 families within four classes. It is worth pointing out that each major group of hosts is characterized by a particular assemblage of temnocephalan species, with host specificity at family level. For example, 17 taxa of *Temnocephala* are associated with three families of freshwater crab hosts (Aeglididae, Pseudothelphusidae and Trichodactylidae), while five *Temnocephala* species are associated with 8 taxa of freshwater shrimps included in three families (Cambariade, Palaemonidae and Parastacidae). Information about the natural history of this endemic genus is key to understanding the role of different factors that shaped its diversification patterns across several hydrological basins in the Neotropics and the possible implications of codivergence with host groups (see below) (e.g. Thompson 2005, Martínez-Aquino et al. 2014b).

In this inventory, only *Diceratocephala boschmai* was detected as an introduced species because of translocation together with their crustacean hosts, the invasive redclaw *Cherax quadricarinatus* in Uruguay (Volonteri 2009a), due to human activities such as aquaculture and breeding of ornamental species (Lodge et al. 2012, Saoud and Ghanawi 2013). According to several authors, *D. boschmai* causes a detrimental economic impact because of an aesthetic effect of the eggs on the body surface of the *C. quadricarinatus* (Herbert 1987, Volonteri 2009a). However, it is more important to mention the detrimental biological and ecological impact of these introduced



**Figure 2.** Map of Latin America indicating the countries where freshwater invertebrate and vertebrate hosts, of four classes, have been studied for neotropical symbiotic temnocephalans. Countries with major to 10 species records in dark grey and minor to 2 in low grey. The numbers in circles indicate the total temnocephalan taxa recorded. Map produced by <http://www.naturalearthdata.com/>, and modified in DIVA-GIS 7.5 (Hijmans et al. 2012) (freely available through [www.diva-gis.org](http://www.diva-gis.org)).

species (e.g. Ahyong and Yeo 2007, Larson and Olden 2012). To date, the values of ecological infection parameters (e.g. prevalence and abundance; see Bush et al. 1997) are unknown not only locally but globally. These parameters are required to measure the effect of this symbiotic association – both introduced species, *C. quadricarinatus* and *D. boschmai* – to detect the extent of the spread of *D. boschmai* to other crustacean taxa, especially endemic crabs in their natural ecosystems (Jones and Lester 1993, Chivavaya 2013, du Preez and Smit 2013). Furthermore, the introduced populations of *D. boschmai* in natural hydrological systems in Uruguay represent a serious problem of displacement to the endemic populations of Neotropical *Temnocephala* species because of interspecific competition between symbiotic organisms (Gelder 1999, Sicard et al. 2006, Witte et al. 2008, Tsuchida et al. 2011, Ohtaka et al. 2012). In this context, the data generated in this checklist can be used to support conservation strategies for freshwater biodiversity (Cardoso et al. 2011a, b, Stendera et al. 2012, Collen et al. 2013).

One hundred sixty eight years have passed since the first description and record of a temnocephalan from the Neotropics (Damborenea and Cannon 2001a), and, currently, ±236 records of temnocephalans have been published. However, considering the number of described species and the time passed, it can be stated that most of the diversity of *Temnocephala* remains yet to be described. There is also a significant number of potential hosts that have not been studied with regards to symbiotic temnocephalans. On the other hand, Schoackaert et al. (2008) mentioned that the few species recorded in South America were mostly recorded up to about 1970. Based on the species accumulation curve (Figure 1), this study shows clearly the increase in knowledge about the biodiversity of the temnocephalan fauna in recent times, but based on all of the information compiled for Neotropical temnocephalans, we show the necessity to continue inventory work. The Neotropical temnocephalan fauna contains 31% of Temnocephalida taxa described at the moment, representing 37 taxa allocated to two genera.

This checklist presents data on almost all the extant species of temnocephalans along their distributional ranges in 11 Neotropical countries, which represents 35% of the total political territories (i.e. countries) in the Neotropics (Figure 2). Argentina, Brazil and Uruguay are the countries with the most records of temnocephalans and with the most endemic species of *Temnocephala*, which are represented by 6, 9 and 4 species, respectively, while Colombia, Costa Rica, Mexico and Peru hold 1, 2, 1 and 1 endemic species, respectively. The relatively high number of records in Argentina, Brazil and Uruguay can imply that in these countries there are more research groups working with turbellarians compared to other Neotropical countries (e.g. Damborenea and Brusa 2008, Volonterio 2010, Amato et al. 2011). Therefore, the values of endemism for these particular countries are subjective – a function of the research effort – and it is probable that the endemism may be increased/decreased in future studies from different Neotropical countries. With regards to its exclusively Neotropical distribution, morphological evidence (mosaic syncytial plates) (e.g. Cannon and Joffe 2001, Damborenea and Cannon 2001b), plus the recorded host specificities shown in this study (Appendix 1), allow for the inference that the biological radiation of *Temnocephala* may be the result of a complex combination of ancestral allopatric speciation processes (as a result of the separation of South America and Australia), plus the diversification of their host groups (e.g. Parastacidae) in South (and subsequent radiation in Central) America. For example, the species of *Temnocephala* associated with mollusks appear to be a morphologically homogeneous group with a phylogenetic structure (Volonterio 2007a, Damborenea and Brusa 2008). On the other hand, the almost exclusive distribution in the Southern Hemisphere of the family to which *Temnocephala* belongs (Temnocephalidae) is noteworthy and alludes to a Gondwanian origin (Gelder 1999, Cannon and Joffe 2001). However, a reliable molecular clock of the Temnocephalida is required to support or reject this hypothesis. Future studies combining research programs in integrative taxonomy (Schlick-Steiner et al. 2010, Ceccarelli et al. 2012, Fujita et al. 2012) with approaches of historical association (e.g. genes, organism and areas; see Page and Charleston 1998) will decipher the evolutionary history of *Temnocephala*.

At least 60 papers have been published dealing with the records of Neotropic symbiotic temnocephalans; however, the scarcity of studies in many countries is clear, and needs to be rectified. For example, some countries comprising complex geographic areas (i.e. Mexican Transition Zone, South American Transition Zone) only have one record of these turbellarians, and the diversity of the four major hosts groups is also unknown (Martínez-Aquino et al. 2014a). Therefore, we contend that future survey work should be strategic, aimed at enhancing the biodiversity inventory, combining identification of the host spectrum with choice of appropriate drainages based on biogeographic, faunistic, and hydro-

logic data and on lessons from other freshwater symbiotic Platyhelminthes (e.g. Pérez-Ponce de León and Choudhury 2010, Martínez-Aquino et al. 2014c).

## Acknowledgements

We thank F.S. Ceccarelli, R. Pérez-Rodríguez, L. Alcalde and L. Negrete for their help during field work. L. García-Prieto for providing literature and specimens for morphological comparison deposited at the CNHE. J. Vigliano Relva help to obtained geographical coordinates. We thank Sean M. Rovito for help with language editing and two reviewers for their constructive criticisms. A.M.-A. is currently supported by a postdoctoral grant from CONACyT, Mexico (No. 207983). This study was supported by grants PIP CONICET 0390 and FCNyM-UNLP N11/728 to C.D. and PIP CONICET 11220120100635CO F.B.

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## Supplementary material

### Appendix 1. Host-symbiont temnocephalans list from Neotropics

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Data type: Microsoft Excel file (xls)

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